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United States
Department of
Agriculture

Forest Service

Summer 1982
Volume 43, No. 3

Fire Management Notes

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Fire Management Notes

An international quarterly periodical devoted to forest fire management

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Department of
Agriculture
Forest Service

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Contents

Fire Management Notes is published by the Forest Service of the United States Department of Agriculture, Washington, D.C. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through September 30, 1984.

Subscriptions may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The subscription rate is $7.50 per year domestic or $9.40 per year foreign. Single copy cost is $2.00 domestic and $2.50 foreign.

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Cover photo: A portable instrument for measuring woody fuel moisture is now available. Story begins on p. 25.

Archiving Remote Automatic Weather Station Data

R. William Furman

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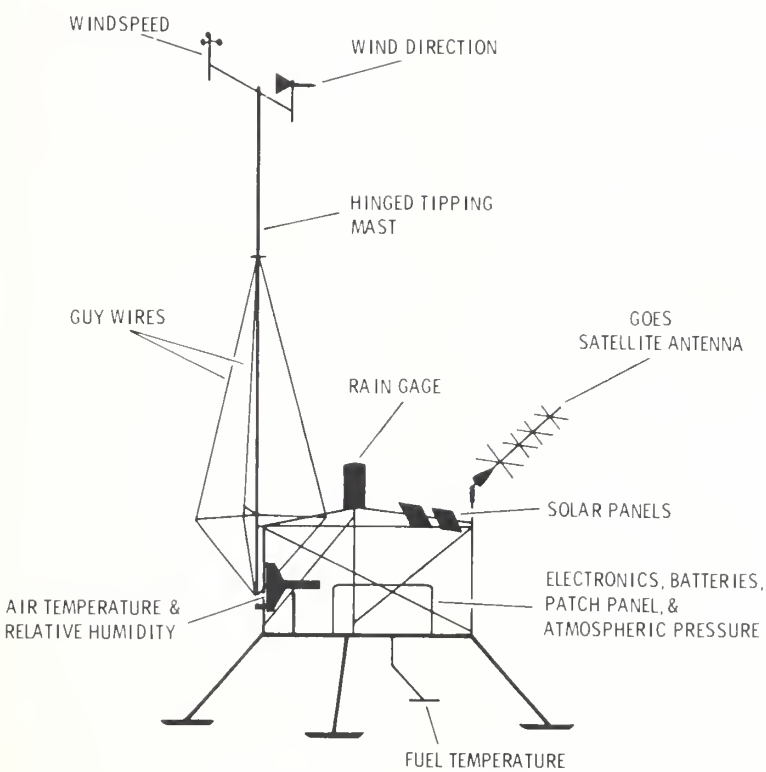
In the past, fire managers have based their planning and decisions on the one observation per day from traditional fire weather stations. Today a vastly superior source of data is available to fire management agencies from remote automatic weather stations (RAWS), which are being acquired at a rapid pace. However, each station takes 4,800 observations during a typical 200-day fire season. And the handling, storage, and retrieval of RAWS data may present a data management problem. The system described here was developed by the Rocky Mountain Forest and Range Experiment Station (RMS) and has been in use for 2½ years.

Why Archive the Data?

Information from traditional fire weather stations is automatically archived in AFFIRMS, the computerized fire danger rating system. At this time, however, data from RAWS are not centrally archived.

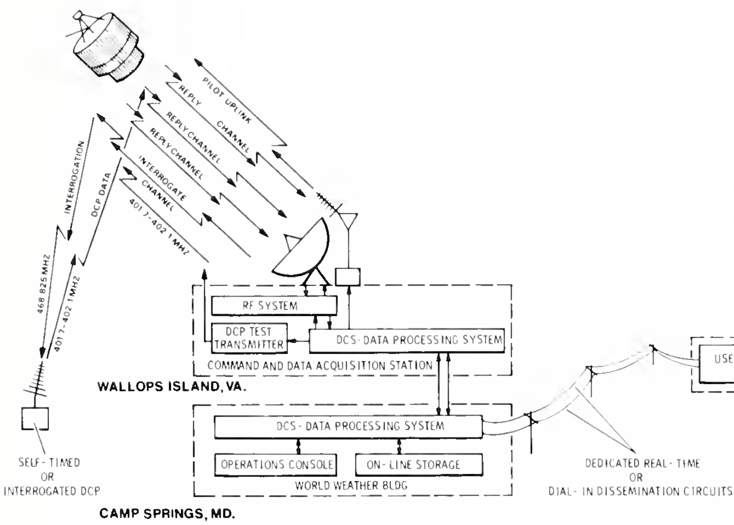


Schematic representation of RAWS.

Thus, the local manager should begin compiling this relevant meteorological data as soon as each RAWS station becomes operational to ensure the data are available when needed. The increased amount of data available from a RAWS archive can provide input for complicated planning problems, including the timing of certain meteorological events, such as the probable onset of east winds in the Pacific Northwest or the time of day a prescription may be satisfied, and the number of hours of prescription weather which may be expected.

The RAWS System

A station takes an observation every hour and stores the data in its memory. Every 3 hours the station transmits the contents of its memory to the geostationary operational environmental satellite (GOES), which immediately retransmits the message back to receiving stations on the ground. Any ground station on the correct frequency can receive the retransmitted observations. The RAWS manager generally receives the data from the weather stations under his or her control by computerized telecommunication from one of two major ground stations. The first of these stations, operated by the National Environmental Satellite Service (NESS) at Wallops Island, Va., sends data to a computer in Camp Springs, Md., for



RAWS data collection platforms (DCP's) transmit weather observations to the geostationary operational environmental satellite (GOES). GOES retransmits observations to ground stations at Wallops Island, Va. and Camp Springs, Md. Data collected through the radio frequency (RF) system is collected, processed, and stored in a data collection system (DCS), then transmitted to user facilities.

temporary storage and distribution to RAWS managers. The manager acquires the data by using a small computer terminal to communicate with the NESS computer. The second ground station of importance to fire managers is operated by the Bureau of Land Management at the Boise Interagency Fire Center (BIFC). The retransmissions are received at the BIFC station, stored on a computer, reformatted, and sent hourly to a special storage file on AFFIRMS. The manager can then retrieve the observations from AFFIRMS.

Neither of these methods of receiving data, however, results in formation of a data base. AFFIRMS can be used to create a limited data base of observations taken at 1 p.m. local time from the RAWS data. To create this limited data base or use it to compute the fire danger indices, the local RAWS manager must manually resend the daily data to AFFIRMS along with the appropriate commands. To archive more than the 1 p.m. data, the local manager must develop a local system similar to the one described here.

Equipment

The data management system in use at the RMS was designed around a Texas Instruments DS990 Model 1 microcomputer. Necessary peripheral equipment includes a dual, 8-inch floppy disk drive, and a 136-characters-per-line printer. This particular microcomputer also requires a 300-baud, full duplex asynchronous modem (Bell 212 or equivalent) or a 1200-baud, half duplex asynchronous modem (Bell 202 or equivalent) to enable the communication between the microcomputer and the NESS computer. A data jack into the telephone set is desirable for both modems, but an acoustical coupler is acceptable for the low-speed modem.

Description of the Data Management System

The data management system (DMS) described here is designed to handle weather observations from Handar remote automatic weather stations or ones with similar data formats. The DMS includes the computer programs necessary to communicate with a host computer, edit the observations received from the host, translate the data into physical units, generate a hard copy of the results, and store the observations on a diskette.

Communications. Two communications programs written at RMS provide low-speed (300-baud) and

high-speed (1200-baud) options. The low-speed program is a general purpose program which emulates a teletype (TTY) terminal and can be used to communicate with most host computers, including the NESS computer. The high-speed program communicates with the NESS computer and provides some internal checking to protect against errors introduced by line noise. Both programs are capable of writing information received from a host computer onto a diskette and onto a line printer. The low-speed program is also capable of reading from a diskette and transmitting that information to the host computer.

Checking, Editing, Sorting, and Storing. After the data are received from the host computer and stored on a diskette, the microcomputer checks them for format integrity. The program detects format errors—such as unacceptable characters, characters out of place, too many or too few channels per line, or lines per transmission—and prints the transmission containing the offense with a code indicating the type of error detected. The program prints and deletes from the file those transmissions which it does not recognize as data or which are from a station not on a list of acceptable stations. The checking program expects data to be in a D3A5 (3 digital and 5 analog channels) or D4A5 format, which is normal for Handar stations. Aside from deleting lines not recognizable as data, the checking program makes no changes in the data. Errors are printed and no further action is taken.

The errors must be corrected by an operator. This is the only part of the operation requiring operator intervention. The operator uses a text-editing program to correct the errors detected by the checking program. When the operator has corrected all the errors, he or she reruns the checking program. If the checking program finds no more discrepancies, control is automatically transferred to a program which sorts the observations first by station number, then by date and time. The program translates information in each observation to physical units and prints it on the line printer in columnar format. The program then appends the data to the archive diskette in a record format similar to that used by the National Fire Weather Data Library (NFWDL) (*1*). The data can be safely stored on these diskettes until such time as a national archive, such as the NFWDL, is available. Each diskette will hold about 14,000 records or observations or nearly one season's worth for three stations.

Summary

With the increased use of RAWS, around-the-clock weather data which were unavailable in the past are becoming available in quantity. These data will soon be invaluable to fire managers and, in particular, to prescribed fire planners because they will permit more accurate planning. No national system is available to collect and save the data; therefore, collection and saving must be done at the local level.

Literature Cited

1. Furman, R. William; Brink, Glen E. The National Fire Weather Data Library: What it is and how to use it. Gen. Tech. Rept. RM-19. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station; 1975. 8 p. ■

Line Production Estimating Guides for Fire Behavior Fuel Models

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Line production estimating guides are needed for initial action planning and estimating control forces required on project fires. Current methods of predicting fire behavior in these situations use fire behavior fuel models (*1*). This article provides line production estimating guides for fuel conditions represented by fire behavior fuel models.

Present methods of estimating line construction rates are best guesses or nomograms constructed from Hornby's adjective fuel rating system. These methods are somewhat outdated because they are not linked to current fuel classification schemes used by fire behavior officers, and they are limited to four fuel conditions.

The tables in this report provide line construction rates covering a wider range of fuel types than past methods and are linked to fire behavior fuel models used in fire suppression work.

These tables have been developed by matching the fuel conditions represented by National Fire Danger Rating System (NFDRS) (*2*) fuel models to similar fuel conditions represented by fire behavior fuel models using Anderson's similarity chart.[1]

The NFDRS fuel model line construction rates are published in Fire Management Analysis and Planning Handbook (*3*).

Limitations

The NFDRS fuel model rates were developed by several people familiar with each fuel type. They were prepared for planning purposes and, therefore, have not been field tested. The fire behavior fuel model rates presented here are suggested for a beginning and should be revised as needed. A knowledgeable local individual should be able to adjust these rates to match local conditions.

The production rates reflect only fuel conditions and do not reflect influences of topography or fire behavior.

The Tables

The tables give line construction rates for hand crews, pumper crews, and bulldozers for each fire behavior fuel model. Rates for initial action and sustained line construction are provided. Where a

Table 1.—*Line production rates for initial action by hand crews* [1]

Fire behavior fuel model	Conditions used in	Construction rate
		Chains per person-hour [2]
1 Short grass	Grass	4.0
	Tundra	1.0
2 Open timber/ Grass understory	All	3.0
3 Tall grass	All	0.7
4 Chaparral	Chaparral	0.4
	High pocosin	0.7
5 Brush (2ft.)	All	0.7
6 Dormant brush/ hardwood slash	Alaska black spruce	0.7
	All others	1.0
7 Southern rough	All	0.7
8 Closed timber litter	Conifers	2.0
	Hardwoods	10.0
9 Hardwood litter	Conifers	2.0
	Hardwoods	8.0
10 Timber (litter and understory)	All	1.0
11 Light logging slash	All	1.0
12 Medium logging slash	All	1.0
13 Heavy logging slash	All	0.4

[1] These rates are to be used for estimating initial action productivity only. Do not use these rates to estimate sustained line construction, burnout, and holding productivity. Initial action consists of scratch line construction and hotspotting.

[2] 1 chain/hr is equivalent to 20.1 meter/hr.

[1] Anderson, Hal E. Aids to determining fuel models for estimating fire behavior. Gen. Tech. Rept. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station; in press.

fuel model can be used in two different situations, rates are given for each. For example, fire behavior fuel model 8 represents fuel conditions expected in compact timber litter, either hardwood or conifer. However, line construction rates in hardwood litter are different from those in conifer litter, so both rates are provided.

Tables 1 and 2 show line production, given a fire behavior fuel model, in chains per hour for initial action for hand crews and pumper crews. These rates should not be used to estimate sustained line construction, burnout, and holding. Initial action rates consider only scratch line construction and hotspotting.

These rates may be used for dispatch planning in a planned area for estimating initial action.

Table 3 contains the line construction, burnout, and holding rates, given a fire behavior fuel model, in chains per 20-person crew hour. These rates are for sustained production over a 12-hour shift on the line. They account for cumulative fatigue and rest periods.

Table 2.—*Line production rates for initial action by pumper crews* [1]

Fire behavior fuel model	Conditions used in	Rates in chains per crew-hour				
		Number of persons in crew				
		1	*2*	*3*	*4*	*5+*
1 Short grass	Grass	6	12	24	35	40
	Tundra	2	8	15	24	30
2 Open timber/ Grass understory	All	3	7	15	21	25
3 Tall grass	All	2	5	10	14	16
4 Chaparral	Chaparral	2	3	8	15	20
	High pocosin	2	4	10	15	18
5 Brush (2ft.)	All	3	6	12	16	20
6 Dormant brush/ hardwood slash	Black spruce	3	6	10	16	20
	All others	3	6	12	16	20
7 Southern rough	All	2	5	12	16	20
8 Closed timber litter	Conifers	3	8	15	20	24
	Hardwoods	10	30	40	50	60
9 Hardwood litter	Conifers	3	7	12	18	22
	Hardwoods	8	25	40	50	60
10 Timber (litter and understory)	All	3	6	12	16	20
11 Light logging slash	All	3	8	12	16	20
12 Medium logging slash	All	3	5	10	16	20
13 Heavy logging slash	All	2	4	8	15	20

[1] These rates are to be used for estimating initial action productivity only. Do not use these rates to estimate sustained line construction, burnout, and holding productivity. Initial action may consist of scratch line construction and hotspotting.

Production rates per person hour are presented parenthetically for estimating production of crews varying from the 20-person standard.

The rates are given in the two crew categories used by the Forest Service. The categories are defined in the footnote to table 3.

These rates may be used to determine control forces required on project fires.

Table 4 contains line construction rates for bulldozers given a fire behavior fuel model and percent slope, in chains per machine hour. These rates do not include burnout and holding of line.

Bulldozer sizes are expressed as Caterpillar models; equivalent models of other makes may use the same rates.

These rates may be used to determine bulldozer needs on project fires.

Conclusions

These estimating guides should prove useful to firefighters in their planning efforts.

When using these guides remember their limitations: The rates are generalized and may need adjustments; A knowledgeable local person may be needed to make adjustments.

Table 3.—*Sustained line production rates of 20-person crews for construction, burnout, and holding* [1]

Fire behavior fuel model	Conditions used in	Crew category [2]	
		I	*II*
1 Short grass	Grass	30 (1.50) [3]	18 (0.90)
	Tundra	9 (0.45)	5 (0.25)
2 Open timber/ grass understory	All	24 (1.20)	16 (0.80)
3 Tall grass	All	5 (0.25)	3 (0.15)
4 Chaparral	Chaparral	5 (0.25)	3 (0.15)
	High pocosin	4 (0.20)	2 (0.10)
5 Brush (2ft.)	All	6 (0.30)	4 (0.20)
6 Dormant brush/	Black spruce	7 (0.35)	5 (0.25)
hardwood slash	Others	6 (0.30)	4 (0.20)
7 Southern rough	All	4 (0.20)	2 (0.10)
8 Closed timber litter	Conifers	7 (0.35)	5 (0.25)
	Hardwoods	40 (2.00)	24 (1.20)
9 Hardwood litter	Conifers	28 (1.40)	16 (0.80)
	Hardwoods	40 (2.00)	24 (1.20)
10 Timber (litter and understory)	All	6 (0.30)	4 (0.20)
11 Light logging slash	All	15 (0.75)	9 (0.45)
12 Medium logging slash	All	7 (0.35)	4 (0.20)
13 Heavy logging slash	All	5 (0.25)	3 (0.15)

[1] Allowances have been made in production rates for rest periods and cumulative fatigue.
[2] Crew category I is Inter-regional hotshot crews; II is all others including FS regular crews.
[3] Chains per person-hour are shown in parentheses

Table 4.—*Sustained line production rates, bulldozer construction*

Fire behavior fuel model	Conditions used in	Percent slope [1] - Bulldozer size [2]: 0 to 25 percent			26 to 40 percent			41 to 55 percent			56 to 74 percent		
		S	M	L	S	M	L	S	M	L	S	M	L
		Chains per machine-hour											
1 Short grass	Grass	70	75	100	54	60	90	40	44	80	24	28	60
	Tundra	[3]	—	—	—	—	—	—	—	—	—	—	—
2 Open timber/ grass understory	Conifers	35	39	50	27	30	45	20	22	40	12	14	30
	Brush-grass	70	78	100	54	60	90	40	44	80	24	28	60
3 Tall grass	All	23	25	40	18	20	35	13	15	30	5	7	25
4 Chaparral	Chaparral	35	43	50	27	30	45	20	22	40	12	14	30
	High pocosin	—	—	—	—	—	—	—	—	—	—	—	—
5 Brush (2ft.)	All	23	25	40	18	20	35	13	15	30	5	7	25
6 Dormant brush/ hardwood slash	Black spruce	28	30	40	22	25	35	18	20	30	10	12	20
	Others	23	25	40	18	20	35	13	15	30	5	7	25
7 Southern rough		—	—	—	—	—	—	—	—	—	—	—	—
8 Closed timber litter	Conifers	28	30	40	22	25	35	18	20	30	10	12	25
	Hardwoods	22	26	30	19	21	27	16	18	17	5	8	9
9 Hardwood litter	Conifers-West	35	39	50	27	30	45	20	22	40	12	14	30
	South	23	25	40	18	20	35	13	15	30	5	7	20
	Hardwoods	22	26	30	19	21	27	16	18	17	5	8	9
10 Timber (litter and understory)	All	23	25	40	18	20	35	13	15	30	5	7	25
11 Light logging slash	All	35	39	50	27	30	45	20	22	40	12	14	30
12 Medium logging slash	All	35	39	50	27	30	45	20	22	40	12	14	30
13 Heavy logging slash	All	23	25	40	18	20	35	13	15	30	5	7	25

[1] Machine use above 74 percent slope assumed infeasible.
[2] S denotes Small (D4-size) bulldozer, M denotes Medium (D6-size) bulldozer, L denotes Large (D7-size) bulldozer.
[3] Machine use assumed infeasible in these fuel types.

Literature Cited

1. Albini, Frank A. Estimating wildfire behavior and effects. Gen. Tech. Rept. INT-30. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station; 1976. 92 p.
2. Deeming, John E.; Burgan, Robert E.; Cohen, Jack D. The National fire-danger rating system—1978. Gen Tech. Rept. INT-39. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station; 1978. 66 p.
3. USDA Forest Service. Fire Management Analysis and Planning Handbook. FSH 5109.19, supplemented, Chapter 90:A-19-A-26. Unpublished draft. ■

The Fuel Management Training Series

Duane R. Freeman

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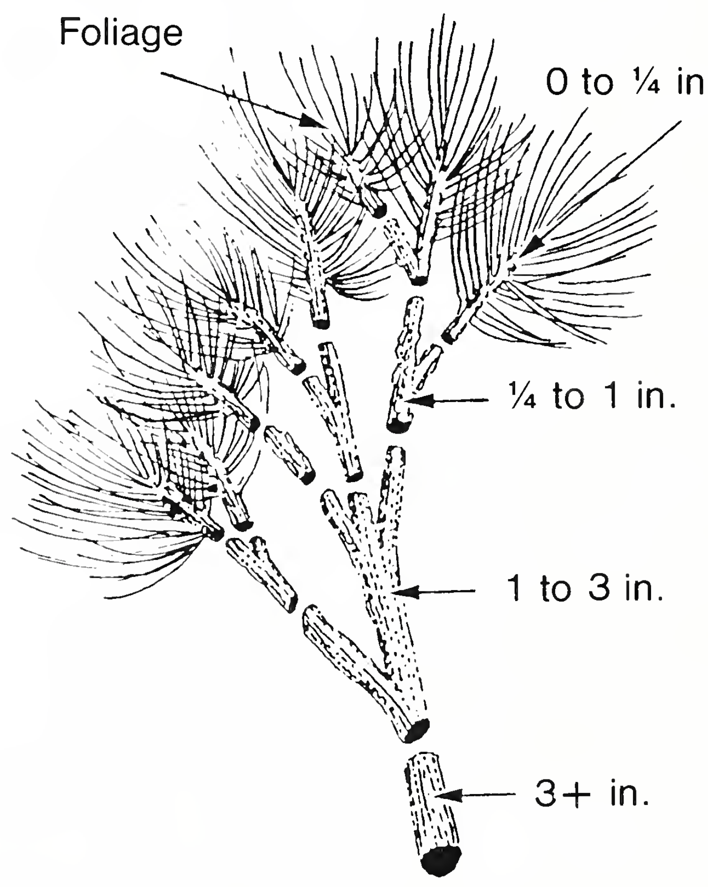
The USDA Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo., and the Division of Aviation and Fire Management, Washington, D.C., have produced a four-part fuel management, slide-tape training series to aid land managers in managing forest activity fuels.

The first slide-tape program explains inventory procedures for existing downed woody fuels; the second provides methods for predicting slash weights from tree-cutting activities; the third gives procedures for obtaining estimates of fire behavior in the predicted slash; and the fourth describes a decision process for evaluating slash treatment alternatives. A short slide-tape overview of the training series is also available.

The training series is designed to enable land managers, foresters, and fuel managers to estimate the weight per unit area of forest fuels for use in predicting fire behavior potential, to estimate the amount of material available for possible energy utilization, and to make better fuel management decisions.

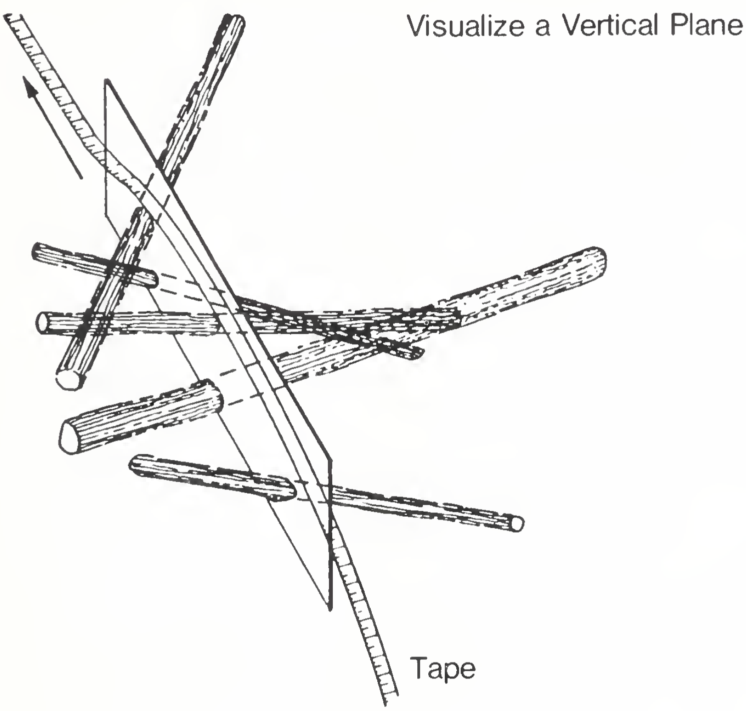


The downed woody fuels inventory involves counting the number of fuel particles by fuel size classes of 0 to ¼, ¼ to 1, 1 to 3, and 3 inches and larger.

Downed Woody Fuels Inventory. The downed woody fuels inventory procedures (*2*) provide an estimate of the existing material on the proposed timber sale area before timber cutting. The inventory involves counting fuel particles by size classes of 0 to ¼, ¼ to 1, 1 to 3, and 3 inches and larger along an imaginary vertical plane projected through the fuelbed.

The procedures for this inventory, based on the line intersect method (*3, 16*) are described in a handbook for field use (*2*). The 10-hour slide-tape training course closely follows Brown's handbook (*2*) and provides the techniques for trainees to measure and calculate the amount of downed woody fuel.

Debris Prediction. After calculating the weight of the existing downed woody materials, the next step is to predict the weight of slash or debris that will result from the planned tree-cutting activities. The procedures described in the 6-hour training course follow those

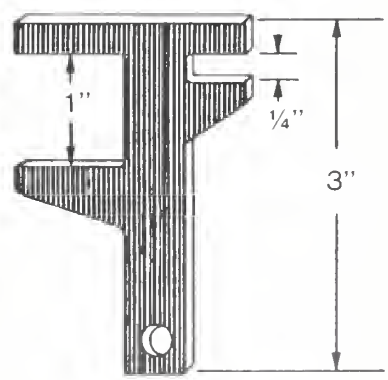


Fuel particles in the downed woody fuel inventory are counted along a transect projected through an imaginary vertical plane at randomly selected sample points. Fuel weights for each fuel size class are then calculated from the number of particles counted, using equations and procedures described in Brown (2).

of Brown and others (*4*) and are based on the relationship of diameter at breast height (d.b.h.) to the weight of tree crowns. While Brown's 1977 handbook (*4*), developed primarily for use in the northern Rocky Mountains, refers only to western species, the same techniques are applicable to other regions including eastern areas, using tables specifically developed for the East (*10*). Snell and Brown (*15*) offer similar tables for trees in the Pacific Northwest.

To make debris predictions, the land manager needs to know the number of trees by d.b.h. class and by species that will be cut in the timber stand. Crown weight tables giving slash weight per tree by species are then used to estimate the weight of debris for each d.b.h. class that is cut. Additional weight estimates are made for debris left as cull and for debris caused by trampling damage during logging. With this information, the manager can predict the total weight of cutting residue per acre and the expected weight of fuel in each fuel size class. This predicted debris information, along with the downed woody inventory information, gives the land manager an estimate of the total amount of woody material by size class that will be on the site after timber-cutting activities.

The manager can use this information to obtain estimates of material that might be used as a source of energy or as other products. The inventory and prediction information also can be used to assess potential fire behavior, making it useful for appraising timber-cutting activity fuel hazards, and analyzing alternative fuel treatment methods.



A go-no-go gage is used for separating borderline fuel size particles and for training the eye. It is not meant to be used to measure every particle.

Predicting Fire Behavior in Activity Fuels. The 6-hour slide-tape training course describes the procedures for predicting fire behavior in activity fuels. It focuses on the use of the computer programs called HAZARD (*12*) and the modified version of HAZARD called FUELBED (*13*), which process input from the fuel inventory, and the debris prediction process to build a site-specific fuel model. While the site-specific fuel model in the programs uses equations developed from logging methods and species of the northern Rocky Mountains and there are limitations in its use, the fuel model and the process have application to other areas as well. Using this fuel bed model, along with the Rothermel (*14*) fire behavior model, the HAZARD program and FUELBED program produce estimates of fire behavior in terms of spread rate, fire intensity, flame length, scorch height, perimeter growth rate, burned area after 1 hour, heat load, and burn time. These estimates allow the land manager to evaluate the relative fire hazard of alternative cutting practices and adjust harvesting plans, if necessary, thereby aiding in the fuel management planning and decisionmaking process.

A Decision Process for Activity Fuels. The 8- to 12-hour slide-tape program describes a decision analysis computer program developed by Hirsch and others (*11*). To evaluate alternative fuel treatment practices, the procedure uses the site-specific fuel model developed from the activity fuel loading information or the stylized fire behavior fuel models (*1*); fire occurrence records and fire weather records to obtain fire line intensity probabilities and chances of spotting for each fuel treatment alternative; and estimates of fire sizes and probabilities provided by local fire experts. Intensity and spotting probabilities and fire size probabilities for the treatment alternatives are then used to construct a fuel analysis decision tree (*13*). The computer program calculates the expected area burned for each fuel type and each fuel treatment alternative within a fuel problem area (*11*). The expected area burned can be thought of as a hazard index. The manager can use this index along with other important decisionmaking information to systematically identify fuel problems, establish priorities for fuel treatment, and provide a documented basis for fuel management decisions.

Summary

The **downed woody fuels inventory** uses a line transect to gather information for estimates of existing downed woody fuel on the site before timber cutting. The **debris prediction** procedures use slash weight tables, timber stand data, and cutting prescriptions, plus information on cull and trampling to give estimates of debris resulting from timber cutting. These estimates can be used in planning for utilizing material for energy production or for other forest products.

The existing and predicted fuel can then be used to construct a site-specific fuel bed model for **predicting fire behavior in activity fuels.**

The site-specific fuel models or stylized fuel models can be used with fire occurrence records and weather records to determine fireline intensity probabilities and spotting probabilities. These probabilities are used with fire size probabilities to obtain expected area burned. **A decision process for activity fuels** shows the fuel manager how to obtain expected area burned for each treatment alternative within a fuel problem area. The expected area burned, along with other important considerations, is used to make fuel management decisions.

The procedures can be useful to private, State, and Federal organizations in appraising forest fuels.

The fuel appraisal procedures briefly covered here are described in detail in slide-tape training programs (*5, 6, 7, 8, 9*) produced by the National Fuel Inventory and Appraisal Project of the Rocky Mountain Forest and Range

Experiment Station at Fort Collins, Colo., and the Division of Aviation and Fire Management, Washington, D.C. Each training package is complete with cassette tape, slide sets, master copies of handouts and viewgraphs, and an instructor's guide. These materials provide step-by-step procedures that enable trainees to accomplish a comprehensive fuel management analysis using handbooks and computer programs. The training programs are available from the National AudioVisual Center, National Archives and Records Service, General Services Administration, Washington, DC 20409.

These fuel analysis techniques can provide a systematic approach to making better fuel management decisions.

Literature Cited

1. Albini, Frank A. Estimating wildfire behavior and effects. General Technical Report INT-30. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station; 1976. 92 p.
2. Brown, James K. Handbook for inventorying downed woody material. General Technical Report INT-16. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 1974; 24 p.
3. Brown, James K.; Roussopoulos, Peter J. Eliminating biases in the planar intersect method for sampling small fuel volumes. Forest Science 20(4):350–356; 1974.
4. Brown, James K.; Snell, J. A. Kendall; Bunnell, David L. Handbook for predicting slash weight of western conifers. General Technical Report INT-37. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station; 1977. 35 p.
5. Freeman, Duane R. Downed woody fuels inventory. Slide-tape training program Title No. A03156. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range and Experiment Station; 1980. Available from National AudioVisual Center, National Archives and Records Service, General Services Administration, Washington, D.C.
6. Freeman, Duane R. Debris prediction. Slide-tape training program Title No. A04148. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range and Experiment Station; 1981. Available from National AudioVisual Center, National Archives and Records Service, General Services Administration, Washington, D.C.
7. Freeman, Duane R. Predicting fire behavior in activity fuels. Slide-tape training program Title No. A06162. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range and Experiment Station; 1982a. Available from National AudioVisual Center, National Archives and Records Service. General Services Administration, Washington, D.C.
8. Freeman, Duane R. A decision process for activity fuels. Slide-tape training program. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range and Experiment Station; 1982b. Available from National AudioVisual Center, National Archives and Records Service, General Services Administration, Washington, D.C. [In press.]
9. Freeman, Duane R. The fuel management training series: An Overview. Slide-tape training program: Techniques for activity level fire planning project. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station; 1982c.
10. Freeman, Duane R.; Loomis, Robert M.; Roussopoulos, Peter J. Handbook for predicting slash weight of trees in the Northeast. General Technical Report NC-78. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station. [In press.]
11. Hirsch, Stanley N.; Radloff, David L.; Schopfer, Walter C.; Wolfe, Marvin L.; Yancik, Richard F. The activity fuel appraisal process: Instructions and examples. General Technical Report RM-82. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station; 1981. 60 p.
12. Puckett, John V.; Johnston, Cameron M.; Albini, Frank A.; Brown, James K.; Bunnell, David L.; Fischer, William C.; Snell, J. A. Kendall. User's guide to debris prediction and hazard appraisal. Missoula, MT: USDA Forest Service, Northern Region; 1979. 37 p.
13. Radloff, David L.; Yancik, Richard F.; Walters, Kenneth G. User's guide to the national fuel appraisal process. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station; 1982. 48 p.
14. Rothermel, Richard C. A mathematical model for predicting fire spread in wildland fuels. Research Paper INT-155. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station; 1972. 40 p.
15. Snell, J. A. Kendall; Brown, James K. Handbook for predicting residue weights of Pacific Northwest conifers. PNW-103. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station; 1980. 42 p.
16. Van Wagner, C. E. The line intersect method in forest fuel sampling. Forest Science 14(1):20–26; 1968. ■

Fire-Weather Station Maintenance—How Good Is It?

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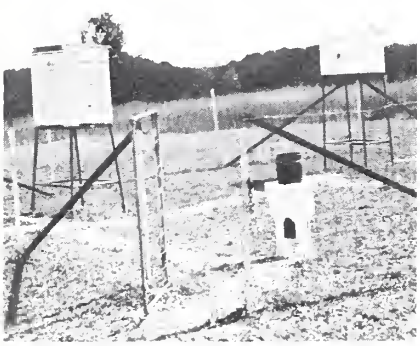
Fire managers depend on the indices and components of the National Fire-Danger Rating System (NFDRS) as guidelines for making presuppression decisions (*2*). Because NFDRS computations depend on weather data, it is important to have a network of properly located and maintained weather stations. We evaluated instrument maintenance at 80 standard fire-weather stations in the Northeastern United States.



A typical fire-weather station.

Collecting Information

The North Central Forest Experiment Station, National Forest System Region 9, and Northeastern Area State and Private Forestry cooperate in a station inspection and NFDRS implementation program. As part of this program, a meteorological technician visits 40 primary fire-weather stations in the 20-State Northeastern Region on a 2-year rotating cycle. These visits supplement those of fire-weather forecasters and State and National Forest fire staff personnel.

We designed a seven-category form for evaluating station maintenance of the instrument shelter, psychrometer, maximum-minimum thermometers, rain gage, anemometer,[1] fuel moisture sticks, and stick weighing device. The form contains 40 checklist items, which conform to standards described in the *Fire-Weather Observers' Handbook* (*3*). Because some items contribute to greater observational error than others, each item is assigned points on a scale of one to five based on its relative importance. We realize that some readers may argue that certain items are more or less important than we designated. This scale represents a compromise among several options. We awarded all or no points for each item.

Although the inspection program is primarily concerned with the 40 network stations, the meteorological technician also inspects other nearby fire-weather stations as time and opportunity permit. This provides a data base consisting of station inspections from 80 northeastern locations. Forty stations have had two to four visits under this program; the other 40 were visited just once.

[1] For a more detailed discussion of anemometer accuracy, see Haines and others (*5*).

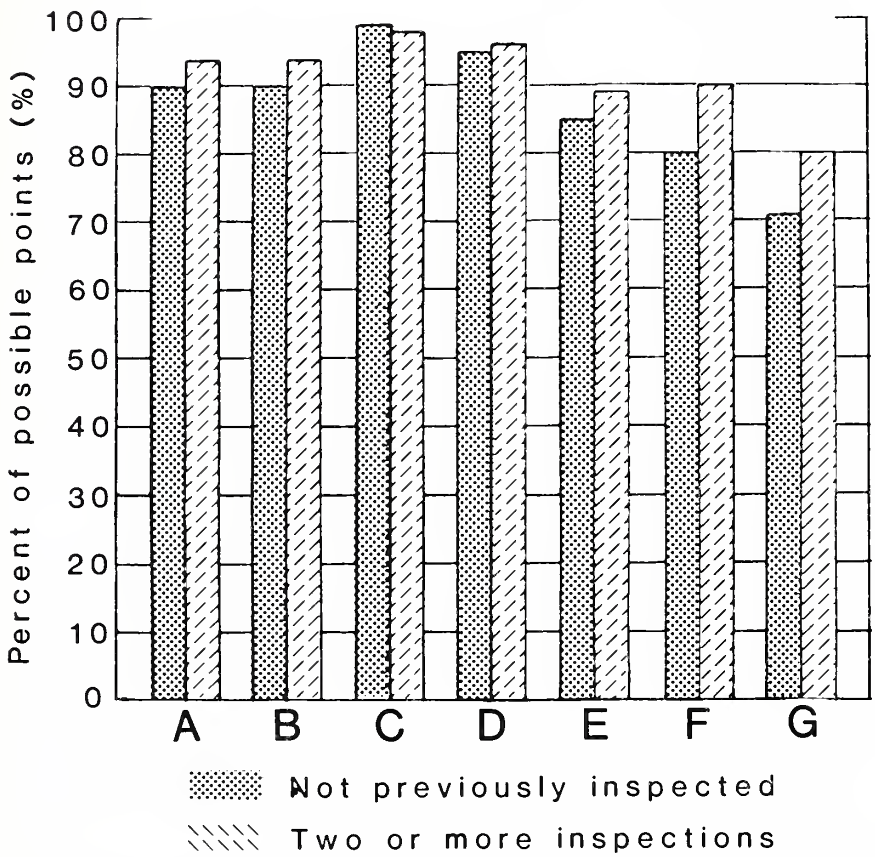
What We Found

We tabulated station maintenance results from these two sets of data and entered them on a scale indicating relative point score (as a percentage of the total possible points). Maintenance standards for the instrument shelter, the psychrometer, the maximum-minimum thermometers, and the rain gage were high—scoring 90 percent or more of possible points. We usually deducted points from shelter maintenance because the shelter needed paint or the inside was dirty. The shelter should be painted glossy white and be cleaned regularly. Occasionally we deducted points because the shelter was near or over unacceptable ground cover. These stations were generally located near the office for convenience, rather than in an area that allowed proper instrument exposure. Points were often deducted from psychrometer upkeep because the muslin wicks surrounding the thermometer bulb were dirty. (Wicks should be replaced at least every 2 weeks.) Few if any problems arose with the maximum-minimum thermometers—as indicated by a 98-percent point score.

Almost all deductions from rain gage scores were the result of improper exposure. Standards require a 45-degree vertical clearance

Instrument Shelter	YES	NO	POSS. PNTS.
Cotton Region ☐ Region 6 ☐ Other ☐			
Door opens to north			5
Painted glossy white--inside and out			3
Dust free--inside and out			1
Houses temperature sensitive instruments only			1
Firmly mounted, level, and plumb			2
Floor 48'' above ground			4
Ground cover Grass ☐ Other ☐			5
Exposed to direct sunlight from 0700-1700			4
Psychrometer	YES	NO	
Electric Fan ☐ Sling ☐ Mortar Board ☐ Other ☐			
Thermometers clean			1
Columns unseparated			5
Wet bulb uncalcified			4
Markings legible			3
Wicking clean			4
Fan working			5
Battery fresh			3
Mortar board level and plumb			4
Reservoir water clean			2
Max/Min Thermometer	YES	NO	
WB Type ☐ U-Type ☐ Other ☐			
Thermometers clean			5
Columns unseparated			5
Markings legible			3
Townsend support spins easily			2
Rain Gage	YES	NO	
8 inch ☐ 4 inch ☐ Recording ☐ Wedge ☐ Other ☐			
Level and plumb			5
Securely mounted			2
Measuring stick legible			5
45° clearance around gage			4
Anemometer	YES	NO	
Stewart ☐ Forester ☐ Friez ☐ Other ☐			
Age of anemometer ______ years			
Exposed correctly			5
Tower plumb and stable			5
Serviced at least twice annually			5
Date last serviced ______			
Counter/Timer operating well			5
Counter/Timer checked regularly			3
Date last calibrated ______			
Fuel Moisture Sticks	YES	NO	
Fence adequate			2
Duff bed 3' x 3' x 2''			5
Duff bed weed free			3
Exposed 10'' above duff			5
Hook pointed north, brads down			2
Sticks changed every ______ months			4
Weighing Device	YES	NO	
Triple beam ☐ Appalachian ☐ Other ☐			
Dust free			1
Calibration checked regularly			5
Scale shelter W/Window ☐ Appalachian ☐ Other ☐			3
Shelter level and secure			4

A seven-category, 40-item inspection form used to evaluate fire-weather stations.



A composite evaluation of maintenance standards for 7 fire-weather instruments at 80 fire-weather stations in the Northeastern United States. Dotted bars show average standards at 40 stations not previously inspected under this program. Bars with dash marks show average standards at 40 stations inspected from 2 to 4 times. The categories: (A) instrument shelter, (B) psychrometer, (C) maximum-minimum thermometers, (D) rain gage, (E) anemometer, (F) fuel moisture sticks, and (G) weighing device.

around the gage. Many observers had not realized that those small seedlings of yesteryear had grown by leaps and bounds and now obstruct the rain gage.

Anemometer maintenance standards were slightly lower than standards found for the first four categories, due primarily to a lack of regular servicing. Anemometers should be serviced at the beginning of the fire season. But if the anemometer is left on the mast throughout the year, the observer should service it at least every 6 months.

We found that general maintenance of fuel moisture sticks and their weighing device was poorer than that of other instruments. The 10-hour fuel moisture is a critical factor in computing the NFDRS, and its measurement needs upgrading. The most frequent infractions in these two categories were either poor duff-bed maintenance or improper weighing methods. Station personnel should fence duff beds and maintain them in the weed-free 3′ x 3′ x 2″ standard. Sometimes observers weigh the sticks in the office and may get erroneous readings. Occasionally, observers forget to return the sticks to the station enclosure, resulting in even greater stick measurement error the next day. To resolve this problem, we suggest building a simple scale shelter to house the weighing device (*1*, *4*).

Repeated station inspection did not improve standards for instruments that were already well maintained. The most noticeable change resulting from a regular inspection program was a 10-percent improvement in maintenance of fuel moisture sticks and their weighing device. Of course, the inspection program assists in other ways. Besides helping observers improve instrument standards, a station inspection allows observers to ask questions they may have about observing procedures and fire-danger rating calculations. Perhaps just as important, a visit demonstrates

that people are really interested in the station and the fire-weather observation program.

How Good Are the Stations?

The data show that high instrument standards are the rule in the categories involving the instrument shelter, the psychrometer, the maximum-minimum thermometers, and rain gage. Comparatively, lack of regular servicing of the anemometers at some stations results in slightly lower standards for that category. The general maintenance of fuel moisture sticks and their weighing device was poorer than that of other instruments. Nevertheless, in total these data suggest that the overall quality of instrument maintenance is good at northeastern fire-weather stations.

How Can We Improve?

We often felt that the difference between a good and a poor station depended on the observer's attitude. Sometimes attitudes can be improved simply by letting observers know that high station standards are both essential and expected. Supervisors at all levels can help by demonstrating to observers that the station is important enough to rate regular visits to discuss problems and answer questions. A supervisor's enthusiasm can be contagious.

Literature Cited

1. Barney, R. J. Appalachian scale shelter. Res. Note INT-88. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1962. 4 p.
2. Deeming, J. E.; Burgan, R. E.; Cohen, J. D. The national fire-danger rating system—1978. Res. Pap. INT-39. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 63 p.
3. Fisher, W. C.; Hardy, C. E. Fire-weather observers' handbook. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1972. 152 p.
4. Frost, J. S.; Haines, D. A. An easy to make shelter for the triple-beam balance used at fire-weather stations. Res. Note NC-208. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1976. 2 p.
5. Haines, D. A.; Frost, J. S.; Klumpp, R. J. A portable instrument to test field anemometers. In: Proceedings, 6th National Conference on Fire and Forest Meteorology; April 22-24; Seattle, WA. Washington, DC: Society of American Foresters; 1980:124-126. ■

International Seminar on Forest Fire Prevention and Control in Warsaw

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On May 20-22, 1981, the Polish Government sponsored an international conference on forest fire prevention and control. This seminar was organized by the Food and Agriculture Organization of the United Nations (FAO), the Economic Commission for Europe (ECE), and the International Labour Organization (ILO) in cooperation with the International Union of Forestry Research Organizations (IUFRO), following a decision by the Joint FAO/ECE/ILO Committee on Forest Working Techniques and Training of Forest Workers at its twelfth session in 1978. The seminar was attended by representatives from 20 nations.[1]

The conference was concerned with the worldwide increase of forest fires, an increase in damaged areas, and the search for solutions to these problems. Within the ECE region particularly affected are the Mediterranean countries where recent forest fires in 1981 devastated large areas of Spain, Greece, and Portugal.

Forest fire statistics are now available that were collected by the Joint FAO/ECE working party on forest economics and statistics (*1*). Twenty-eight European countries, the United States, and Canada participated in the evaluation of these data. Since the data refer to different time spans, however, comparisons over periods longer than 10 years are not possible.

In Europe the strong effects of weather on the occurrence of wildfires during the fire season can be demonstrated with the Federal Republic of Germany. During the dry year 1975, a total of 8768 ha of forests was destroyed by fire, while in 1978 only 289 ha were burned.

Although 1978 was a year of low fire incidence in the Federal Republic of Germany, circumstances were critical in southern Europe. Spain, Italy, Portugal, France, and Greece alone reported fires from a total area of 726 916 ha. Among these, 354 469 ha were classified as forest and other wooded land.[2] The remainder included non-forested land such as the shrub type ("Macchia" or Chaparral plant communities), heather or grasslands. Spain reported the highest losses during the same year totalling 434 668 ha, from which 160 000 ha were high forests.

Tables 1 and 2 show data from the forest fire statistics for some European countries. These data indicate the area and number of fires from 1970 to 1979. Even

Table 1.—*Forest fire statistics for Europe, 1970–79* [1]

Country	Total forested area	Statistical period	Annual average number of forest fires	Annual average area burned
	1000 hectares			*hectares*
Sweden	27,301	1971–79	2,889	3,513
Finland	22,371	1970–79	544	952
France	16,600	1974–79	5,470	45,683
Spain	14,092	1970–79	4,195	[2] 156,672
Norway	9,242	1970–78	1,381	594
Poland	8,551	1970–79	1,910	2,613
Greece	8,460	1974–79	885	27,824
Italy	7,993	1970–79	6,426	[3] 87,009
Federal Republic of Germany	7,210	1970–79	2,050	2,806
Czechoslovakia	4,453	1972–79	835	1,002
Austria	3,675	1970–78	263	260
German Democratic Republic	2,953	1970–78	1,148	1,656

[1] Statistical information from: Economic Commission for Europe (ECE) and Food and Agriculture Organization (FAO). Forest fire statistics. Document TIM/EFC/WP.2/R.41. Warsaw, POLAND: ECE and FAO. 1981; Rico-Rico, F. Forest firefighting in Spain. Allg. Forst. Z. 36: 689–690. 1981.

[2] Total area burned. Other statistics from F. Rico-Rico's article show an annual average of 57,818 ha of burned forest and other wooded land from 1961 to 1978.

[3] Total area burned, including nonforest land. About 40% (34,803 ha) are classified "forest and other wooded land."

[1] Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, German Democratic Republic, Federal Republic of Germany, Hungary, Italy, Norway, Poland, Portugal, Republic of Korea, Spain, Sweden, Tunisia, USSR, and the United Kingdom.

though the statistical information may be incomplete and sometimes includes nonforested land damaged by fire, the tables show the gross differences between the Mediterranean and other European countries.

One measure of the relative seriousness of the forest fire problems in different countries is the area damaged by fire within a given year in relation to the total area of forest and other wooded land.[2] In Spain, for instance, the area burned in 1978 was 1.25 percent (tables 1 and 2). Portugal reported 1.87 percent burned in 1978.

The economic and ecological effects of the forest fires are particularly serious in the Mediterranean countries because fires jeopardize sustained yield policies and afforestation programs. In Spain, a comparison of waste land afforestation projects (which averaged 57 818 ha annually between 1940 and 1978) and the amount of forest land destroyed by fire (about 57 818 ha annually between 1969 and 1978) shows how strongly it would affect the success of afforestation efforts.

[2] Timber Committee, Economic Commission for Europe (ECE) and Food and Agriculture Organization (FAO). European timber trends and prospects, 1950 to 2000. Rome, ITALY: ECE and FAO; 1976. 308 p.

Table 2.—*1978 fire year in Europe* [1]

Country	Total forested area	Forested area burned	Percentage of total forested area burned	Value of losses
	1000 hectares	*hectares*		*1,000 U.S. dollars*
Sweden	27,301	1,591	0.006	760
Finland	22,371	801	0.004	728
France	16,600	46,701	0.34	100,796
Spain	14,092	[2] 175,631	1.25	350,156
Norway	9,242	[2] 141	0.15	144
Poland	8,551	2,054	0.02	1,500
Greece	8,460	19,972	0.24	60
Italy	7,993	44,000	0.55	16,288
Federal Republic of Germany	7,210	289	0.004	592
Czechoslovakia	4,453	339	0.008	210
Austria	3,675	135	0.004	299
German Democratic Republic	2,953	631	0.02	574

[1] Statistical information from: Economic Commission for Europe (ECE) and Food and Agriculture Organization (FAO). Forest fire statistics. Document TIM/EFC/WP.2/R.41. Warsaw, POLAND: ECE and FAO. 1981

[2] Total includes forest and nonforest land.

The causes of forest fires in different countries also varied a great deal in comparison with the causes of those in Germany (table 3). For instance, the percentage of unknown causes is very high compared to the unknown causes in Germany. The current information listed in the ECE/FAO statistics for 1978 and contributed by 20 European countries is strongly influenced by the Mediterranean countries. Among known causes of forest fires in 1978, arson counted for 68 percent in Portugal, 70 percent in Spain and 50 percent in Italy. Reasons for the enormous increase in fires caused by arson are to be looked for in social, economic and political areas. In Spain, arson often results from (*2*): the opposition of animal raisers and shepherds to afforestation activities; dissatisfaction with hunting yields; political opposition of people against the administration; and attempts to intimidate and damage the government.

The effects of politically motivated arson were demonstrated in

Table 3.—*Causes of forest fires in Europe and the Federal Republic of Germany*

Causes	Europe 1978	Germany (1972–78)
	- - - - Percent - - - -	
Unknown	46	32
Negligence	20	39
Arson	28	12
Lightning	1	1
Other	5	16

Greece when in the beginning of August 1981, forest fires were set all over the country at one time.

International Topics of Interest

The conference focused on the need for education and new developments in techniques and equipment for forest firefighting. Fundamentals in silviculture and forest ecology and the need for basic research were also discussed. The need for better mutual information in Europe is clearly recognized, perhaps the reason being that the activities in research, development, and education within Europe have been strongly dissipated. This, unfortunately, has also led to an obvious isolation from the development in North America.

International cooperation. Participants at the symposium demanded better information exchange and more cooperation, and recommended the formation of a committee of experts from the FAO/ECE/ILO work with IUFRO: to collect and disseminate information on the organizational structures and division of responsibilities in participating countries for forest fire control; to prepare a bibliography on selected studies and articles relating to forest fire prevention and control; to prepare a directory of research institutes and other bodies or individuals concerned with research on forest fires (in collaboration with IUFRO); to prepare internationally accepted warning signs and symbols about forest fires because of the growth of international tourism; to organize a systematic arrangement for the exchange of information between countries on new developments in ground and airborne equipment for protection against fires; and to collect and disseminate information on methods of and material used for informing the public about forest fires.

Fire research. The conference participants recommended concentrating research on: the influence of silvicultural methods on forest fire behavior and forest fire danger; the impact of fire on the forest ecosystem; methods for mapping forest fire risks and the relationship between such maps and other ecological mapping; developing models for predicting forest fire danger; and developing models of fire behavior and prediction of fire behavior in both natural and manmade forests.

The Polish Forest Research Institute suggested a dictionary in four languages (English, French, Polish, Russian) in order to emphasize a stronger East-West cooperation (*3*). For the central and south European region and simultaneously for North and South America a glossary in four languages is being prepared (English, French, Spanish, German). This glossary was recommended by the North American Forestry Commission. It will be based on the updated forest fire glossary of the USDA Forest Service, and the USDA Forest Service will act as secretary. Also the Forest Service of Spain (ICONA), the Station de Silviculture Méditerranéenne in Avignon, France, and the University of Freiburg, Federal Republic of Germany, will participate.

Technology transfer. Opportunities for a more intensive European cooperation in technology transfer are now possible through the third program cycle of the United Nations Development Program Regional Programs for Europe (1982-86). The UNDP/ECE included a project on forest fire control in May 1981.

The attention of the ECE countries will also be directed to the necessity of technology transfer in countries belonging to other regions, especially developing nations. The replacement of natural vegetation types by pine plantations and other afforestation efforts creates new forest fire problems in those regions. At the seminar, a German research and development project in South America was described (*4*).

Germany: Research and Development

Heavy wildfires in 1975–76 provided an opportunity to investigate the ecological effects of forest fires in the burned areas. In 1975, research projects were begun in the Eschede area (Lower Saxony, northern Germany) with several institutions of the Gottingen University and the Forest Research and Experimental Station of Lower Saxony participating. The research concentrated on a burned site of Scots pine forest. Special observations were made on the effects of the fire on the soil complex and the successional development following the fire (*5*).

A working group in fire ecology was established within the German Society of Ecology to pursue fundamental research on fire ecology. In 1977 a symposium on fire ecology, sponsored by the Volkswagen Foundation, was held at the Freiburg University. Results of research projects, domestic and foreign, are now published (*6*).

The firefighting kit for the TRANSALL aircraft, which was commissioned by the German Federal Minister for Research and Technology, has been improved in its efficiency and safety (Fire Management Notes, Volume 40, No. 4, 1979). This project was presented in 1980 at the Symposium on Airborne Firefighting in Hannover (*7*). The proceedings of that international conference are already published in German and will soon be available in English.

Literature Cited

1. Economic Commission for Europe (ECE); Food and Agriculture Organization (FAO). Forest Fire Statistics. Document TIM/EFC/WP.2/R.41. Warsaw, POLAND: Economic Commission for Europe (ECE) and Food and Agriculture Organization (FAO). 1981.
2. Rico-Rico, F. Forest Fire Fighting in Spain. Allg. Forst. Z. 36: 689–690; 1981.
3. Forest Research Institute. Forest fire prevention and control vocabulary (English, French, Polish, Russian). Warsaw, POLAND: Forest Research Institute, Joint Economic Commission for Europe (ECE), Food and Agriculture Organization (FAO), and International Labour Organization (ILO); 1981. 103 p.
4. Goldammer, J. G. Controlled burning for stabilizing pine plantations. In: Document TIM/EFC/WP.1/SEM.10/R.5. Warsaw, POLAND: Economic Commission for Europe (ECE), Food and Agriculture Organization (FAO), and International Labour Organization (ILO); 1981: 1–5.
5. Special issue on forest fire with 13 contributions and English summaries. Fortwissenschaftliches Centralblatt [Forestry "Newsletter"] 99: 249–392; 1980.
6. Forest Zoological Institute, Freiburg University. Proceedings, Symposium on fire ecology. Freiburg, W. GERMANY: Freiburg Forest Protection Paper 1(1): 1–159; 1978.
7. Federal Ministry for Research and Technology. Combatting fire and other catastrophies from the air. In: Proceedings, International Science and Technology Symposium, Hannover, W. Germany, 1980. Verlag Bernecker Melsungen; 1981: 1–242. ■

The Scan Extender—A Device to Enhance the Capabilities of the AGA 750 Thermovision

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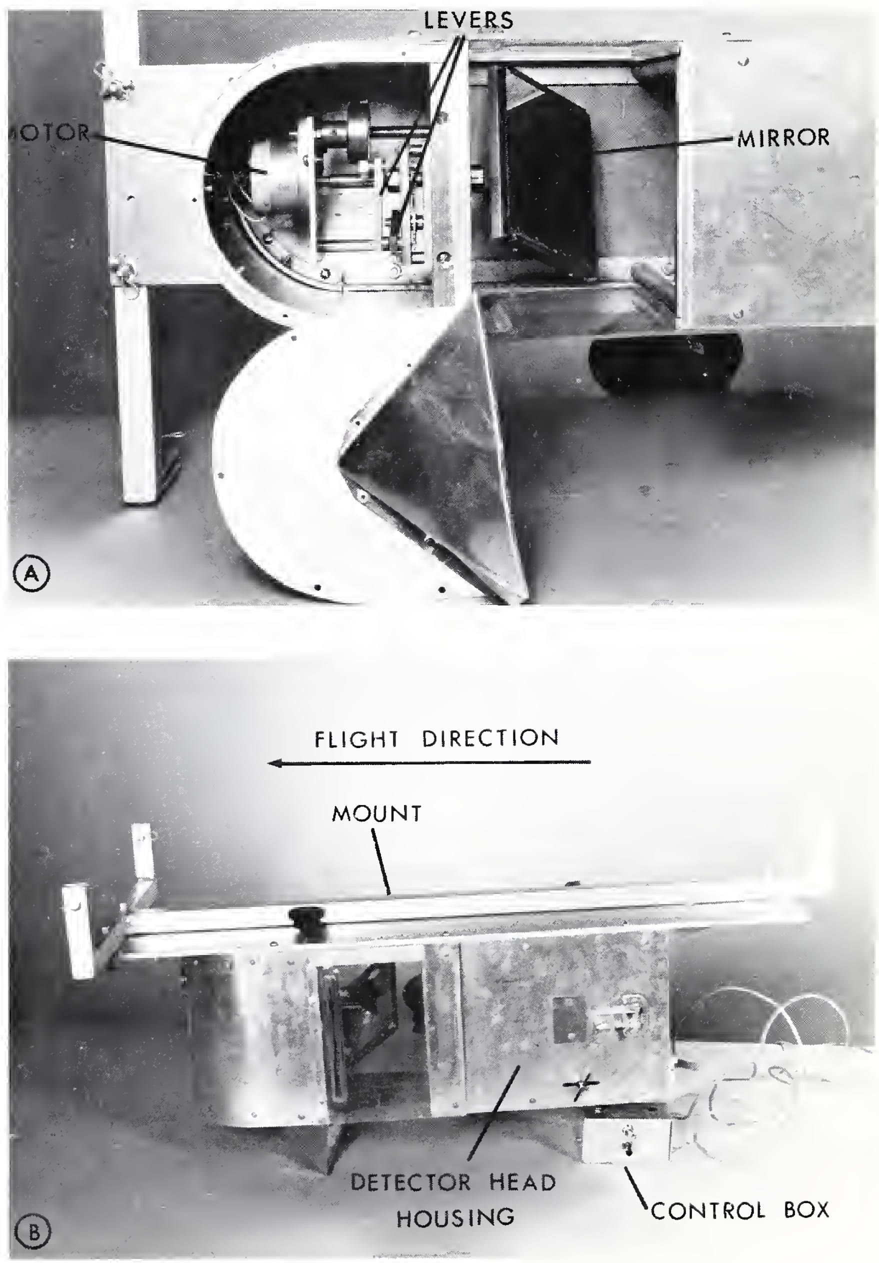
The AGA 750 Thermovision has proved to be an effective instrument for detecting hotspots from the air during forest fire mopup operations (*1*, *3*). However, in situations where several square miles of terrain must be searched, the usual method of holding the detector head by hand or using a super viewer is time consuming and therefore very costly. The Northern Forest Research Centre (NoFRC) has developed an apparatus that allows the Thermovision to be used to search large areas systematically and efficiently.

Design

The scan extender consists of an aluminum box approximately 25 inches long by 6.5 inches wide by 8 inches high (63.5 cm × 16.5 cm × 20 cm), that is mounted beneath an aircraft and encloses the AGA detector head, a 4 inches × 4 inches (10 cm × 10 cm) surface silvered mirror, and a mechanism that oscillates the mirror in a 90-degree arc. The mirror is mounted in front of the detector head at a 45-degree angle and reflects thermal radiation from the ground into the detector. The mirror is powered by a variable-speed, reversible, 12-volt motor and a gear set that together give a maximum output shaft speed of 30 revolutions per minute (rpm). The motor turns an eccentric that changes the rotary motion into the reciprocal



Two views of the scan extender.

movement used to oscillate the mirror. The mirror will make approximately one sweep per second when the motor is running at maximum speed. The mirror is operated from inside the aircraft with a switch box that houses three controls: a two-position switch to start the mirror and let it run in one direction, a rheostat to control the sweep speed, and a three-position return-to-off switch that will run the mirror in either direction and is used for making fine adjustments to pinpoint specific areas. Power for the scan-extender motor is supplied by a NoFRC power pack (*2*), also carried inside the aircraft.

The scan extender has been extensively field tested on Bell 206B helicopters. The apparatus attaches to the helicopter with a mount that is designed to use the aircraft cargo hook attachment points. The scanning equipment can be installed in approximately 15 minutes and requires no modifications to the aircraft. By designing different mounts, almost any helicopter or fixed-wing aircraft can be used as a platform for the scan extender.

Details on the construction of the scan extender and mount are available on request.[1]

[1] For details, contact the Northern Forest Research Centre, 5320–122 Street, Edmonton, Alberta, Canada T6H 3S5. Phone (403) 435-7210.

Operations

Depending on the size of the area to be searched, the detail required, and the aircraft used, speed and height ranges of 50 miles per hour (mph) (80 km/h) ground speed at 2000 feet (608 m) above ground level (AGL) to over 100 mph (160 km/h) at 4,000 feet (1216 m) AGL have proved to be the most practical. Circumstances may occur, such as the need to search a small area thoroughly or to get a quick look at a large area, that will necessitate exceeding this range. Under normal conditions, however, slower speeds and lower altitudes can increase the search time to unacceptable levels, and faster speeds or higher altitudes increase the chances of missing small hotspots.

The mirror operates in a 90° arc and therefore laterally sweeps an area that is equal to twice the flying height. For example, at 4,000 feet (1216 m) AGL the mirror will sweep 1.5 miles (2.4 km) laterally. This combined with a 100 mph (160 km/h) forward speed will result in 2.55 square miles (6.6 km^2) being scanned per minute.

With the mirror operating at the high rate of speed necessary to provide at least two views of any given ground feature, watching the viewing screen can be confusing. After a reasonable period, however, an operator with previous experience on the Thermovision should readily adapt and be capable of a thorough search. In addition, ground detail is usually not important during a general search, so the Thermovision level control can be turned to darken the screen, making ground detail almost indistinguishable and the screen easier to monitor. When a hot area is discovered, the mirror can be slowed down or stopped and the level adjusted to provide background information to aid in locating the hotspot.

During a mopup operation the entire area of concern is searched with the scan extender and any hot areas are noted on a map of the fire. Then, using either the Thermovision camera in the handheld mode (after removing it from the scan extender) or another handheld scanner such as a Hughes Probeye or an AGA 110, only the areas that were shown by the scan extender to contain hotspots are searched, and each pinpointed hotspot is marked for the ground crews.

Effective use of the scan extender results in simpler and more reliable systematic searches in a shorter period of time. The oscillation of the mirror is mechanical and therefore consistent, allowing the operator to plan adequate overlap and thus be certain that the entire search area is being scanned. In addition, only one operator is required to conduct a search, and there is no need to open a window in the aircraft.

Limitations

Using a scan extender has a few limitations. The first is that using the Thermovision at long range decreases the chances of its responding to weak signals, which could result in very small hotspots going undetected.

To determine the minimum spot size that could be detected, a test was run using piles of 1, 2, 4, 6, 8, 10, and 15 briquets. The piles were scanned from progressively higher altitudes, starting at 1,000 feet (304 m) AGL and going up to 7,000 feet (2128 m) in 1,000-feet (304-m) intervals. The resulting thermal information was recorded on videotape for later study. It was found that from 2,000 feet (608 m) AGL, four briquets were easily detected, two briquets were visible but could be missed, and one briquet was missed. At 4,000 feet (1216 m), eight briquests were readily detected, four would possibly be missed, and two would probably be missed.

In addition, the scan extender was used operationally on some 20 wildfires of up to 250,000 acres (101 250 ha). During this work, no new hotspots were discovered after a scan, indicating that under the conditions prevalent at the time of the searches, the equipment was used successfully to locate all of the potentially dangerous spots.

The scan extender also makes it difficult to pinpoint a hotspot in featureless terrain. Unless there are thermally distinctive ground features such as bodies of water, the only reference the operator has is the position of the aircraft in relation to the target. However, even a general location narrows the search area to where a hand-held scanner can quickly pinpoint a hotspot.

Conclusions

The scan extender has been used for two seasons in Saskatchewan for about 60 hours and has proven to be a reliable, useful accessory to the Thermovision. Using it for mopup will save helicopter time and still provide a thorough thermal search.

Literature Cited

1. Niederleitner, J. Detecting holdover fires with the AGA Thermovision 750 infrared scanner. Inf. Rep. NOR-X-151. Edmonton, AB: Environ. Can., Can. For. Serv., North. For. Res. Cent.; 1976. 14 p.
2. Niederleitner, J.; Bihuniak, P. A heavy duty 12-volt dc power pack to operate airborne remote sensing systems. NOR-X-147. Edmonton, AB: Environ. Can., Can. For. Serv., North. For. Res. Cent.; 1976. 10 p.
3. Ogilvie, C. J. Guidelines for use of the AGA Thermovision in forest fire mopup operations. For. Manage. Note 8. Edmonton, AB: Environ. Can., Can. For. Serv., North. For. Res. Cent.; 1981. 6 p. ■

A Belt Weather Kit Accessory for Measuring Woody Fuel Moisture

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A standard belt weather kit (*7*) contains instruments used to obtain pertinent fire weather data. However, the kit contains no provision for obtaining information on fuel moisture, a basic fuel property related to fire behavior and subsequent fire effects.

Several methods are used to estimate fuel moisture. These include weighing fuel moisture sticks (fuel moisture analog) and mathematical modeling techniques; these techniques are indirect and nondestructive. Destructive laboratory methods include gravimetric oven-drying process, Karl Fischer titration, and distillation, usually with xylene. Recently, two field techniques have been evaluated; these are microwave drying (*3*, *4*) and the COMPU-TRAC oven (*5*). Although these methods are useful in research they are expensive, and not well adapted to fireline use. This note describes a commercially available, inexpensive instrument that has been a useful weather kit accessory in west Texas.

The instrument is the Protimeter Moisturemimi, a small, resistance-type moisture meter. The meter is available from several timber supply houses and retails for about $120.00. Its measuring range is 6 to 28 percent moisture content and is accurate to within ±2 percent. It is powered by two 9-volt batteries and has a light-activated, automatic on/off switch concealed under a snap-off cover. It is small

The moisture meter is small, durable, and fits well in existing belt weather kit pockets.

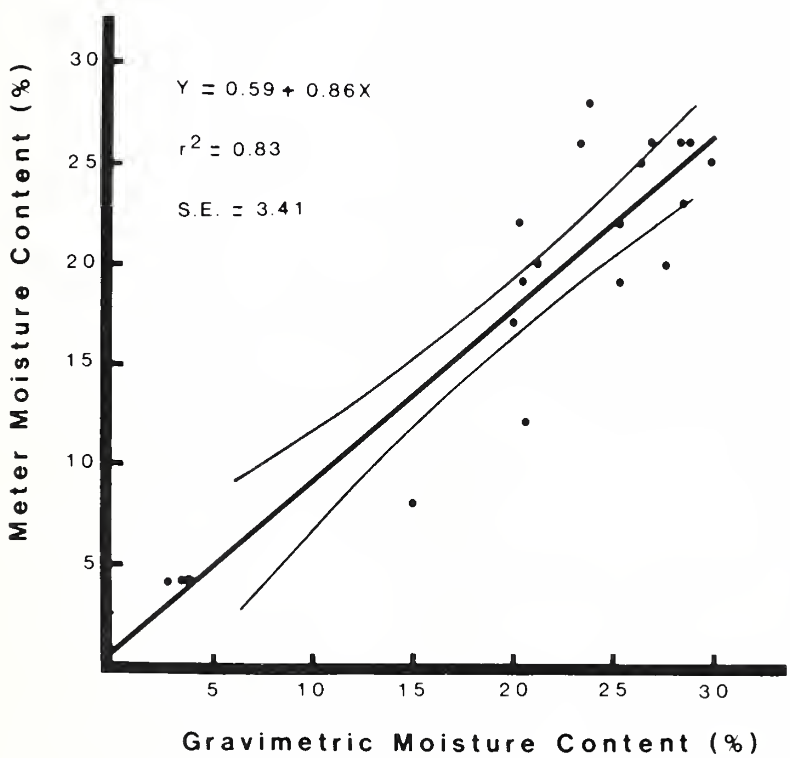
enough for pocket or weather kit use, durable enough for fireline use, and works well at night if firelight or artificial light is provided for the light-activated switch. Installed probes are ½ inch long, and an accessory hammer probe with 1 inch probes is available at extra cost.

The meter has been used when burning chained, redberry juniper (*Juniperus pinchotii*) piles in firelines in west Texas. Since these piles are burned under conservative conditions, ignition is occasionally difficult. Using the meter, it was determined that the brush piles ignite readily if wood moisture is 6 percent or less, and will not ignite if moisture content is above 28 percent. Weather conditions and fire fuel load determine whether wood at moisture contents between 6 and 28 percent will ignite.

For burning honey mesquite (*Prosopis glandulosa* var. *glandulosa*), the meter was calibrated for ½ to 1 inch mesquite roundwood by immersing 20 mesquite samples in water for 72 hours, then drying the samples at 140° F. Periodically, four or five randomly selected samples were removed from the oven, weighed, and moisture readings obtained by inserting the meter probes $^{1}/_{16}$ inch into the samples. This process was accomplished within 30 seconds of removal from the oven, and continued until 20 samples had been weighed. All samples were subsequently dried for 36 hours to obtain dry weight and allow calculation of moisture content. A desorption calibration curve was then developed for dead, mesquite roundwood. Since the meter usually read less than gravimetric results we suspect the difference was due partially to the moisture gradient across the roundwood (*6*). Magnitude of error will likely increase with roundwood diameter; thus, results presented here should not be extrapolated to larger fuel size classes or greater moisture contents. Judging from these results it appears that 12 random samples should provide a reliable indication

of woody fuel moisture content and can be related to gravimetric moisture content when calibrated. A minimum of 20 samples should be used for calibration.

Moisture determination with electric meters depends on the species of wood involved, moisture content, temperature, grain angle, wood density, and other properties (*1*). Thus, some preliminary testing of the meter is required. Alternately, the meter could be calibrated with fuel moisture sticks, or calibration tables supplied with the meter could be used. The meter, however, should be useful in prescribed burning, slash disposal, and fire control under a variety of burning conditions for particular fuel complexes.



Desorption calibration curve for moisture meter on ½ to 1 inch mesquite stems. Regression equation, 5% confidence belt, r^2, and standard error of estimate according to Little and Hills (2).

Literature Cited

1. James, W. L. Electric moisture meters for wood. Gen. Tech. Rep. FPL-6. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Lab.; 1975. 27 p.
2. Little, T. M.; Hills, F. J. Agricultural experimentation: Design and Analysis. New York: John Wiley & Sons, Inc.; 1978. 350 p.
3. McCreight, R. W. Microwave ovens for drying live wildland fuels: an assessment. Research Note PSW-349. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest For. and Range Exp. Station; 1981. 5 p.
4. Norum, R. A.; Fischer, W. C. Determining the moisture content of some dead forest fuels using a microwave oven. Research Note INT-277. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 7 p.
5. Sackett, S. S. An instrument for rapid, accurate, determination of fuel moisture content. Fire Manage. Notes 41(2):19-20; 1980.
6. Skaar, C. Water in wood. Syracuse wood science series 4. Syracuse, NY: Syracuse Univ. Press; 1972. 218 p.
7. USDA Forest Service. Belt weather kit. Fire Cont. Notes 20(4):122-123; 1959. ■

Fire Programs

Prescribed Burning Assistance Program Combats Incendiary Wildfire

The Florida Division of Forestry (FDF) has established a prescribed burning assistance program to combat incendiary wildfire. The Statewide program is the result of a project begun in June 1979 with $10,000 from a National Initiatives Project grant. The FDF provided free prescribed burning assistance to landowners in Clay County, Fla., a high incendiary fire occurrence county, to see what effect it would have in subsequent fire occurrence.

The prescribed burning assistance package included all plan preparation, plowing, and burning at an estimated cost of $2.40 per acre. Clay County has a long history of burning for open cattle grazing purposes, and although burning for this purpose generally ceased in the late fifties, people continue to set fires. Statistics from recent years show that 75 percent of all fires were caused by local residents.

Landowners who agreed to participate in the project signed agreements relieving the FDF of any liability. All burning was done by FDF crews closely following a prescription. Approximately 150 miles of fireline was constructed and 4,720 acres were burned on 10 landholdings. The burning was done between September 1979 and January 1980.

Statistics showed an average of 150 fires for the past 5 years in Clay County, and an average of 94 fires in the first 6 months of each year. The first 6 months of 1980 following the project, a total of 63 fires were reported, even though the months from January through April are traditionally the worst fire months in Florida. Incendiarism was down from a 5-year average of 94 fires to 46 during this 6-month period.

While it is doubtful that a fuel management program alone will solve the incendiary problem in Florida, fuel management, in combination with active fire prevention and aggressive law enforcement may have a more lasting effect.

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Althaus, Irene A.; Mills, Thomas J. Resource values in analyzing fire management programs for economic efficiency. Gen. Tech. Rept. PSW-57. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1982. 9 p.

Carlton, Donald W.; Pickford, Stewart G. Fuelboard changes with aging of slash from ponderosa pine thinnings. J. For. 80(2):91–93; 1982.

Ebarb, Patrick A.; Reeves, Hershel C. Rural fire protection in Texas. J. For. 80(7):414–415 & 419; 1982.

Gray, Gary Craven. Radio for the fireline: a history of electronic communications in the Forest Service. FS-369. Washington, DC:U.S. Department of Agriculture, Forest Service; 1982. 304 p.

Harrington, Michael G. Estimating ponderosa pine fuel moisture using national fire-danger rating moisture values. Res. Pap. RM-233. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1982. 7 p.

Liebson, John. Keep the dollars flowing to your volunteer fire department. Western Fire Journal 34(5):35–37; 1982.

Marty, Robert J.; Barney, Richard J. Fire costs, losses, and benefits:An economic procedure. Gen. Tech. Rept. INT-108-FR-29. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 40 p.

Wood, Donald B. Fuel management's potential for reducing frequency of large fires in the northern Rockies. J. For. 80(2):96, 105–107; 1982. ■